E09-005: 12GeV Moller Status Update

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June 12, 2009

E05-009: 12GeV Moller Status Update

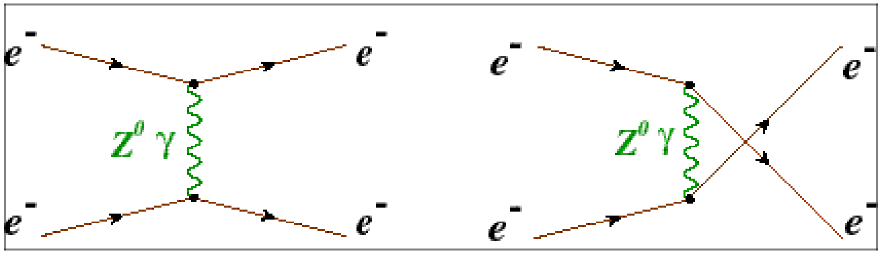
Outline

- Intro: (fully approved at PAC34)
    - Moller Scattering, A_{PV} Measurement
    - Proposed Measurement Details
    - Goals and Motivation
- Experimental Setup/Design
    - Details: Beam, Target, Spectrometer
    - Simulation Studies
    - New Challenges
- Timeline and Status

12GeV Moller Collaboration

- ∼100 authors from 30 institutions, with veterans from all the Jlab parity violating experiments

Moller Scattering, A_{PV} Measurement

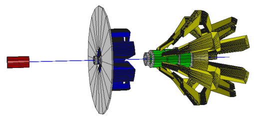


- Purely leptonic reaction provides clean probe of weak neutral current interactions via parity violating electroweak interference

$$A_{PV} = m_e E_{lab} \frac{G_F}{\sqrt{2}\pi\alpha} \frac{4\sin^2\theta}{(3+\cos^2\theta)^2} Q_W^e, \quad (1)$$

$$Q_W^e \equiv 4 \cdot g_V^e \cdot g_A^e = (1 - 4\sin^2\theta_W) \quad (2)$$

- e^-_{beam}: 11GeV, 85μA, 85% polarization
  $\rightarrow \langle Q^2 \rangle = 0.0056\ (\mathrm{GeV/c})^2$, $\langle A_{PV} \rangle = 35.6$ppb
- For 38 week run: $\delta(A_{PV}) = 0.74$ppb, $\delta(Q_W^e) = \pm 2.1(\mathrm{stat}) \pm 1.0(\mathrm{syst})$:
  $\rightarrow \delta(\theta_W) = \pm 0.00026(\mathrm{stat}) \pm 0.00012(\mathrm{syst}) \sim 0.1\%$ precision!



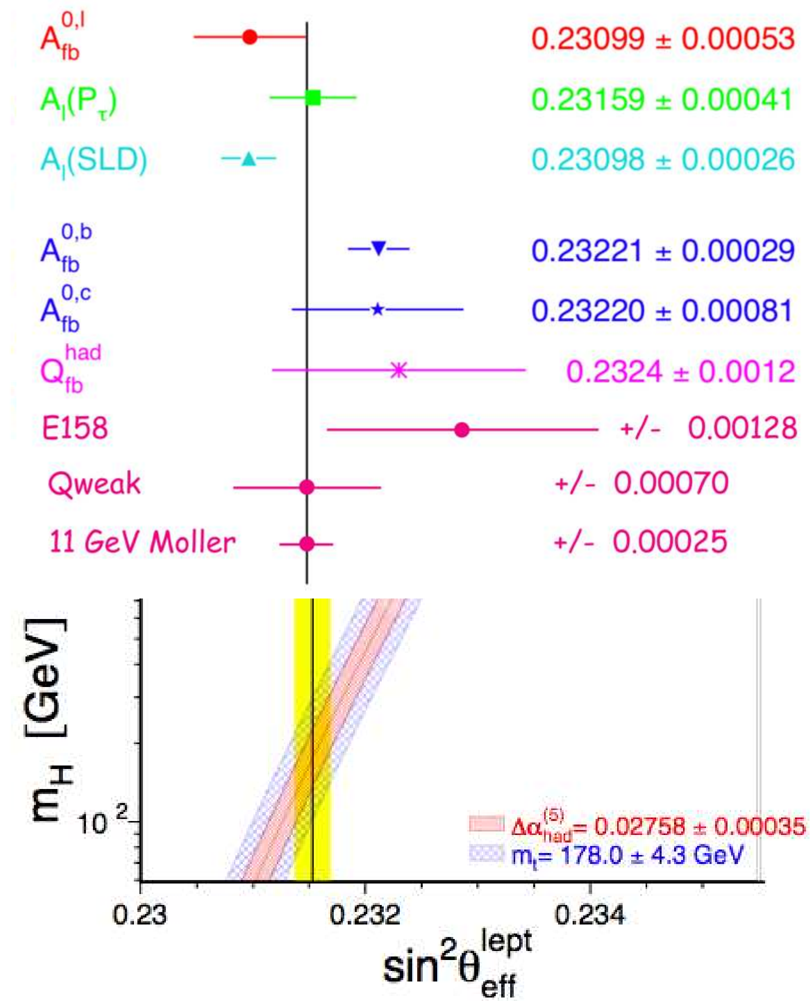
Physics Motivation: $\sin^2\theta_W$, the Higgs Mass, and Beyond the Standard Model

- World data avg: $\sin^2\theta_W = 0.23122(17)$
  $\Rightarrow m_H = 89^{+38}_{-28}$ GeV
  (favors SUSY, rules out Technicolor)
- Avg dominated by two measurements separated by 3σ:

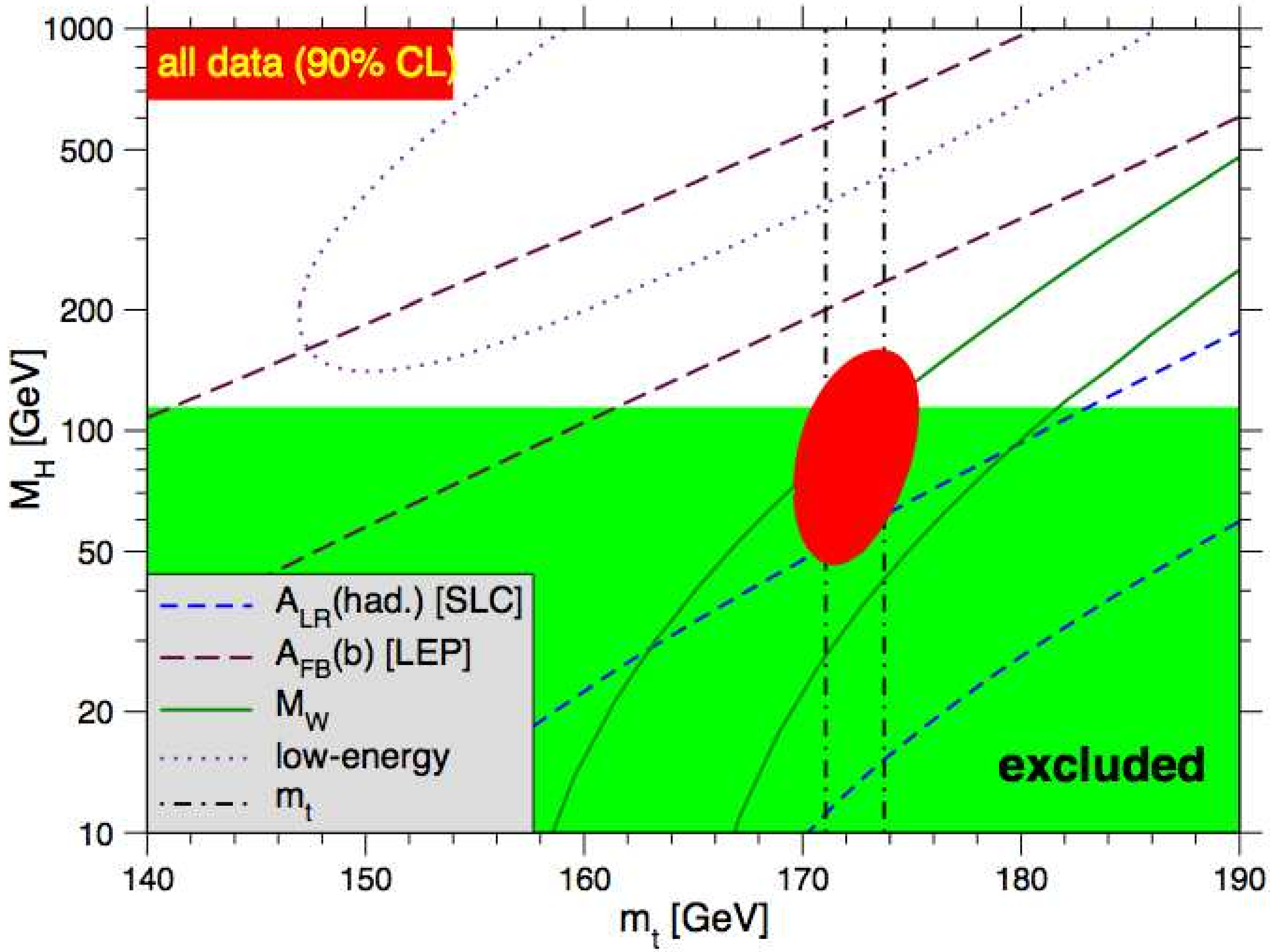
$\rightarrow$ A_l(SLD) : 0.2310(3), $\Rightarrow m_H = 35^{+26}_{-17}$ GeV
rules out SM!

$\rightarrow$ $A_{fb}^{0,1}$: 0.2322(3), $\Rightarrow m_H = 480^{+350}_{-230}$ GeV
rules out SUSY, favors Technicolor

- Proposed measurement precise enough to effect the central value of $\sin^2\theta_W$ and its implications for m_H



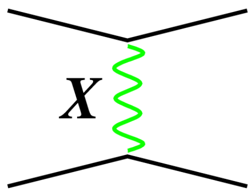
The Search for the Higgs



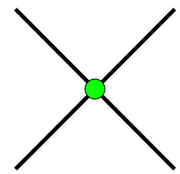
Establishing Limits for New Contact Interactions (Off the Z Resonance)

Important component of indirect signatures for"new physics"

consider



$$A_X \;\alpha\; \frac{1}{Q^2 - M_X^2} \longrightarrow \quad \sim \frac{4\pi}{\Lambda^2}$$



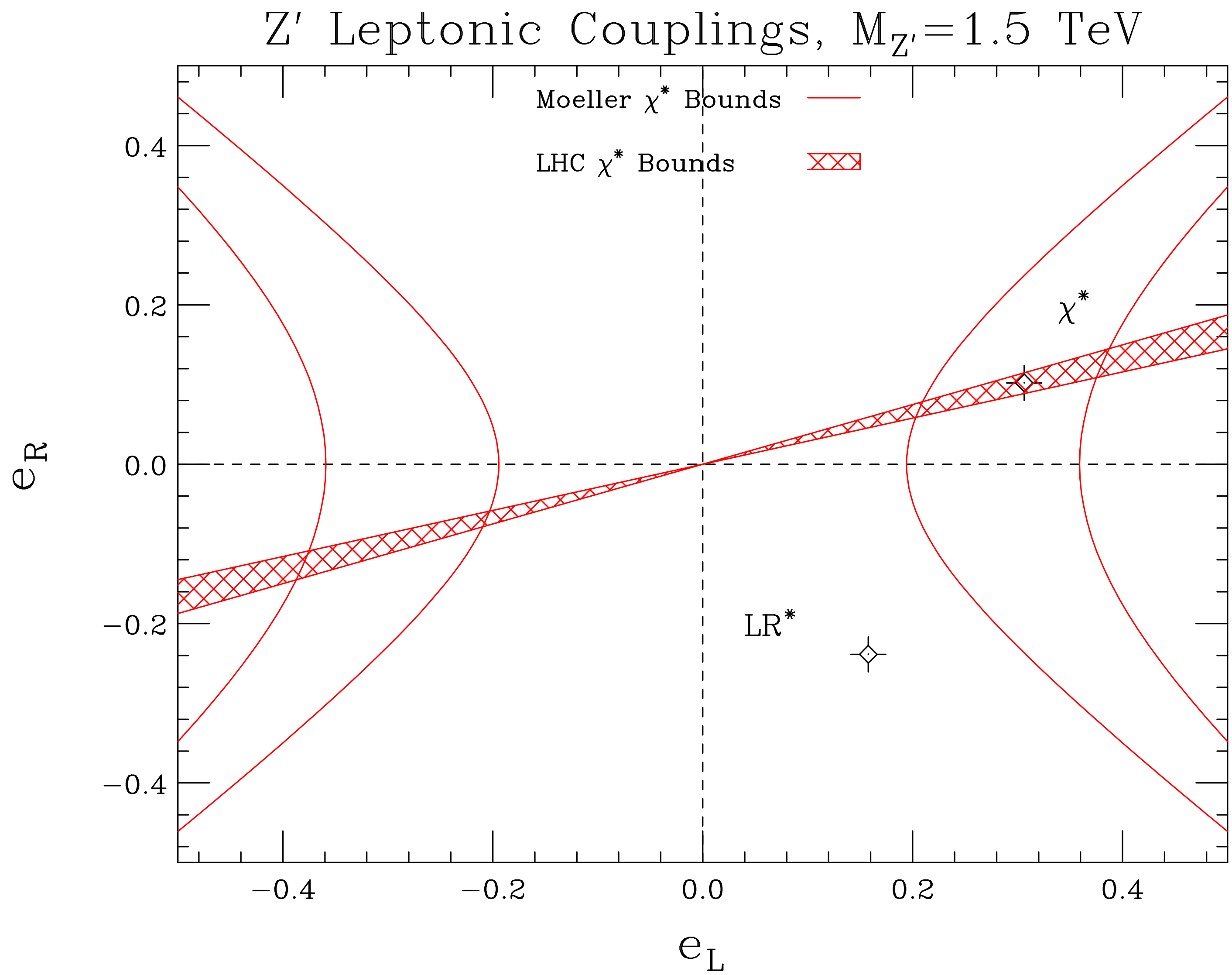
Contact interaction

$Q^2 \sim M_Z^2$ **on resonance:** A_Z *imaginary* $\longrightarrow A_Z^2\left[1+\frac{A_X^2}{A_Z^2}\right]$

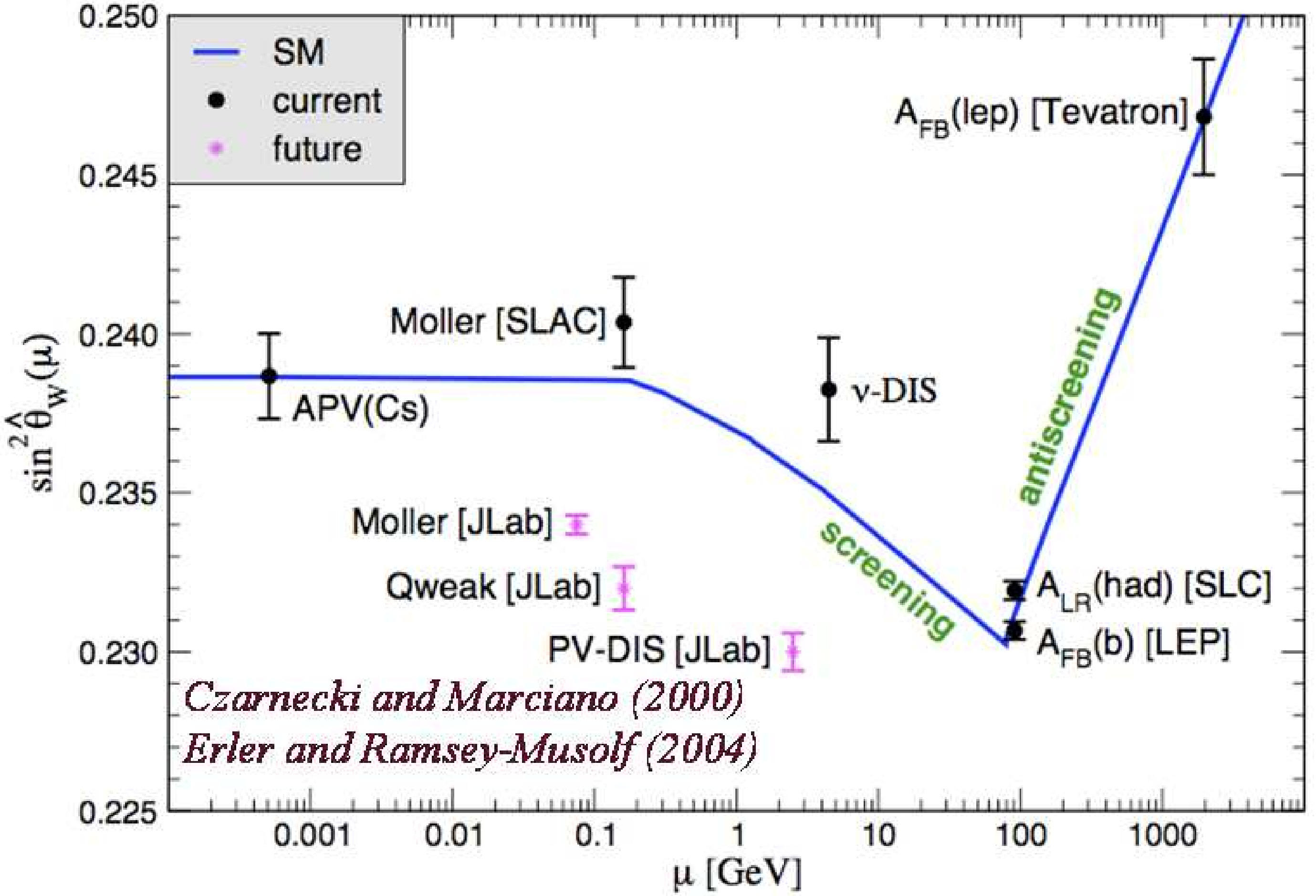
no interference!

- Near the Z resonance, new physics interactions (e.g. Z'_X exchange) don't visibly mix with standard model A_Z (Collider Experiments)
- This underscores importance of low energy measurements of Q^e_W: E158, Qweak, PVDIS, and 12GeV Moller
- Best current limits on $4e^-$ contact interac. come from LEP, LEPII: $\Lambda/g \sim 5$ TeV, but insensitive to $|g^2_{RR} - g^2_{LL}|$
- Proposed Measurement will reach $\sim$ 7.5TeV interaction scale

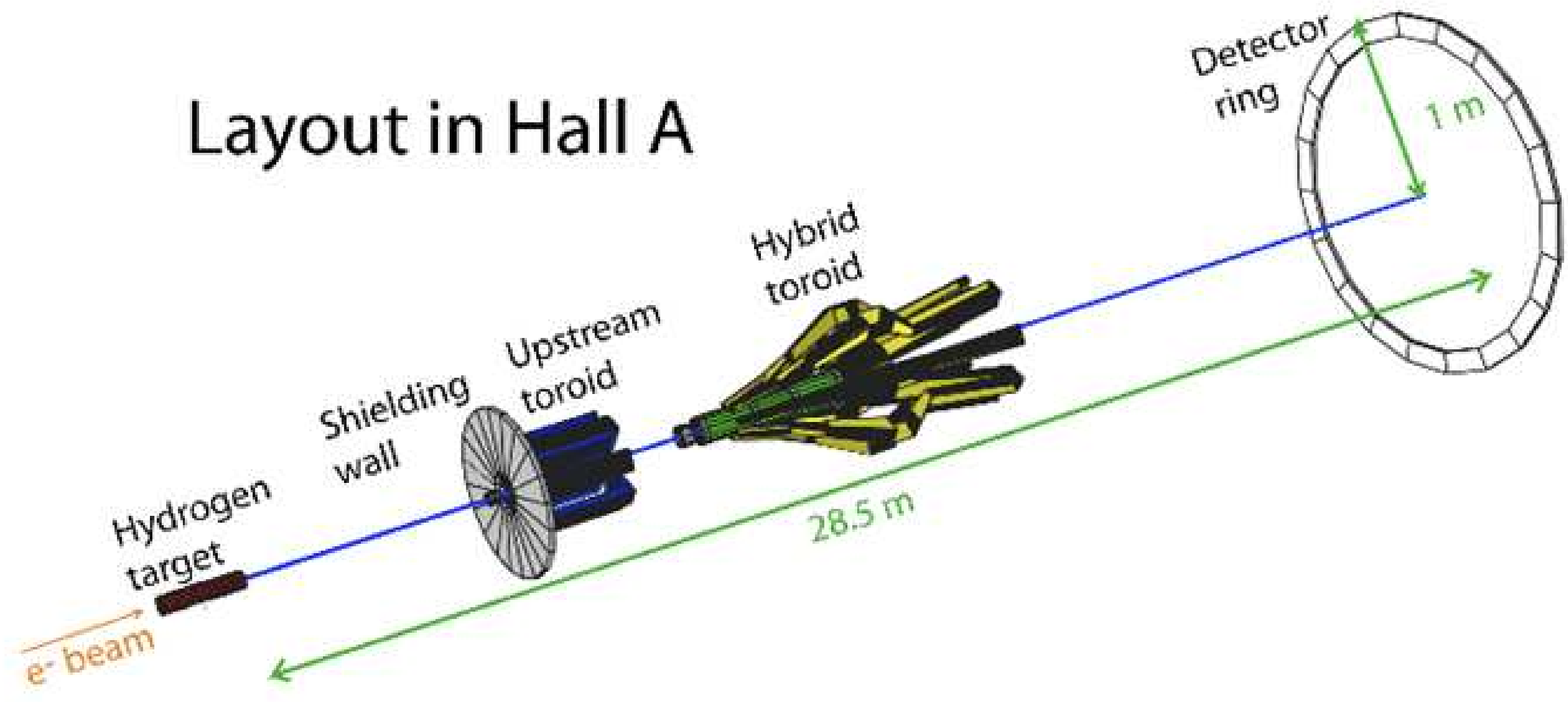
Complimentary Measurement to LHC



Current and Future $\sin^2\theta_W$ Measurements

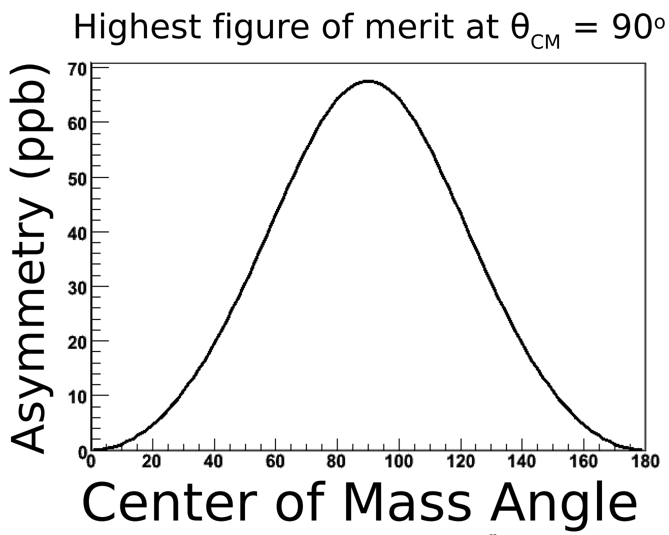


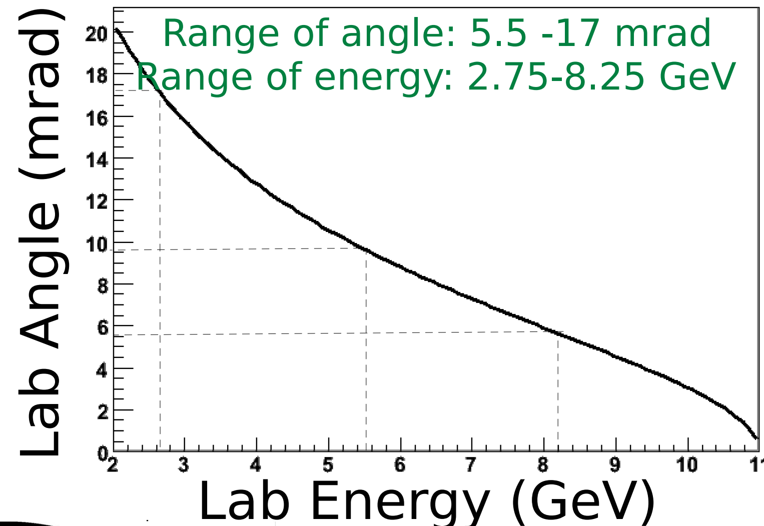
Experimental Setup/Design



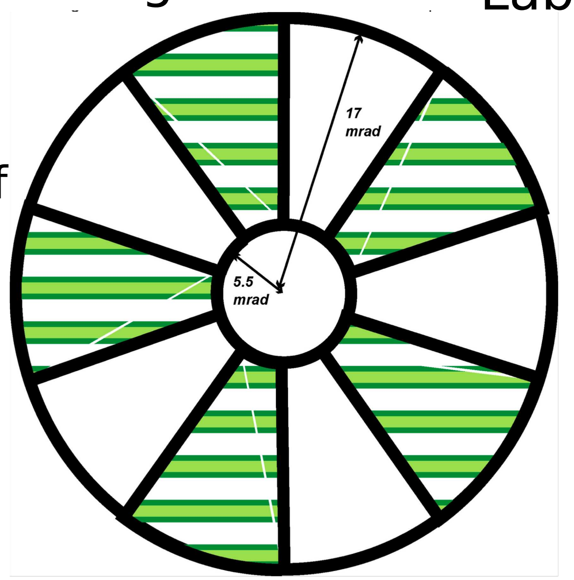
- Long and skinny design (∼30m from target to detector)
- 150cm lH_2 target
- Novel two toroid spectrometer design (prebender and hybrid) with full azimuthal acceptance
- Flux integrating detector ring with azimuthal and radial segmentation

Optimized Spectrometer (~ 100% Acceptance)

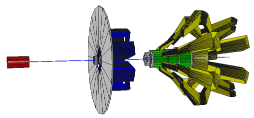




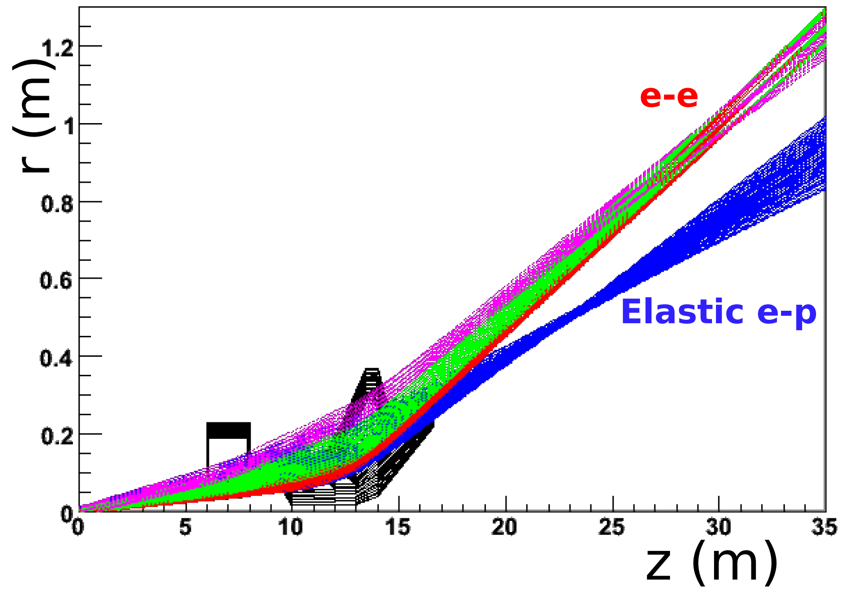
All of those rays of θ_{CM}=[90,120] that you don't get here...

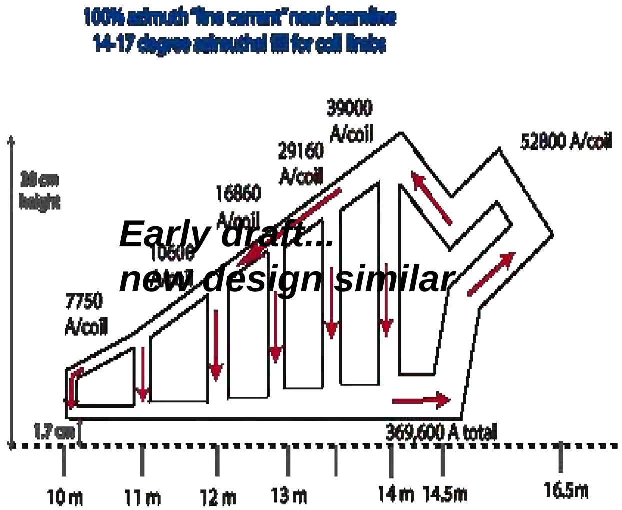


... are collected as θ_{CM}=[60,90] over here!

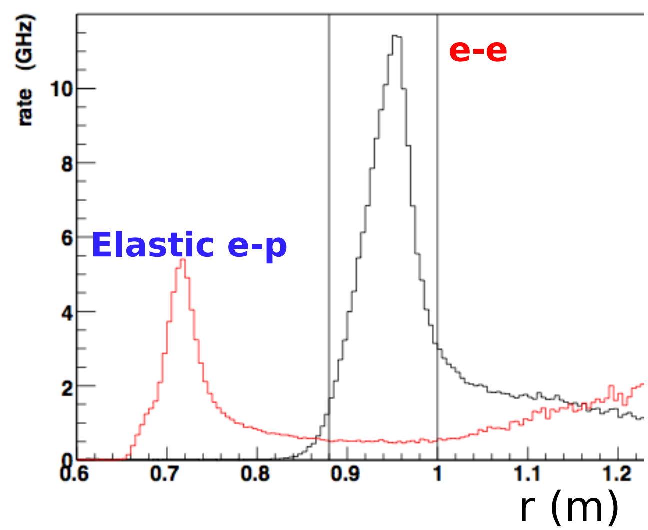


Toroid Design Concept

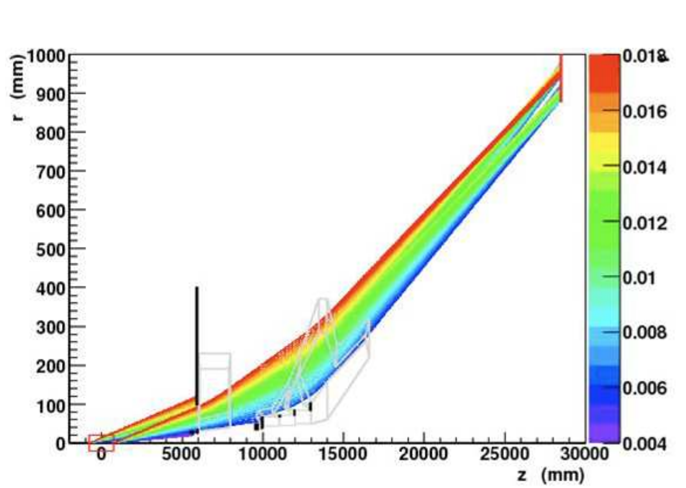




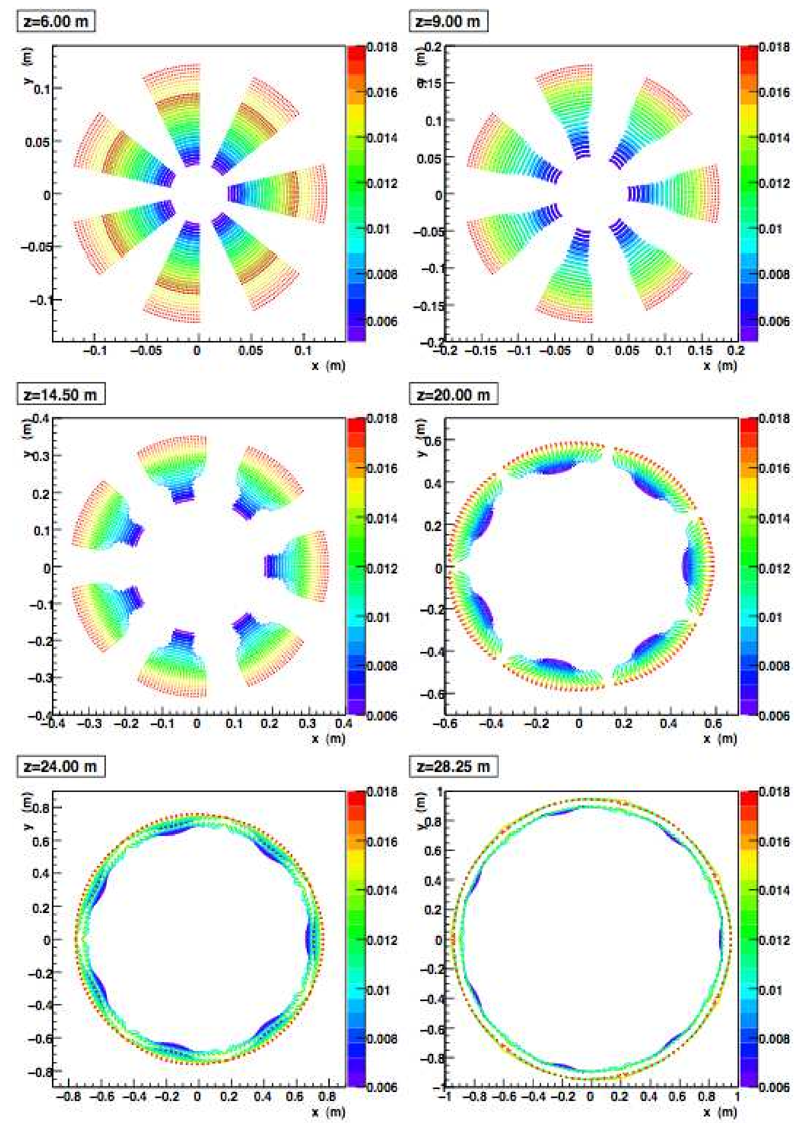
--Two Toroid design facilitates signal and bkgd separation while focusing Moller events onto narrow detector ring



Optics Raytrace

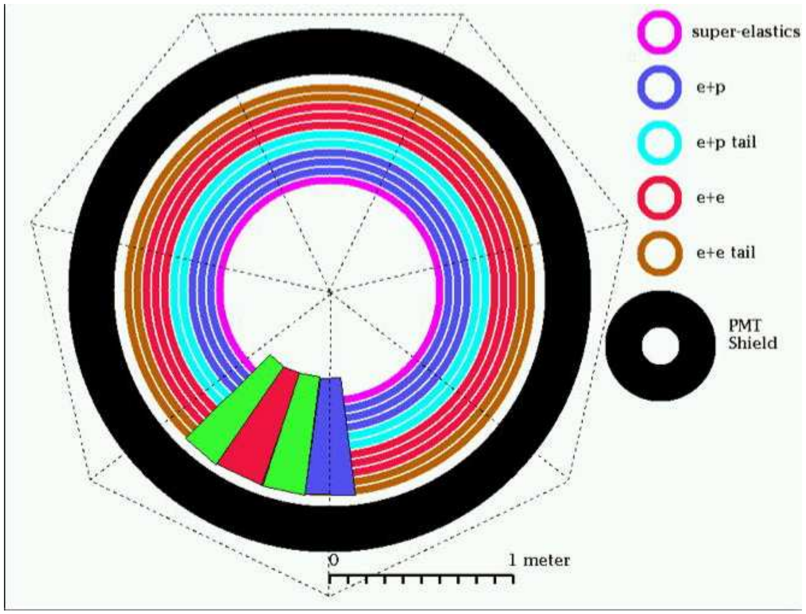


--Defocusing effects results in population of full azimuth



Main Detector Reference Design

Front View

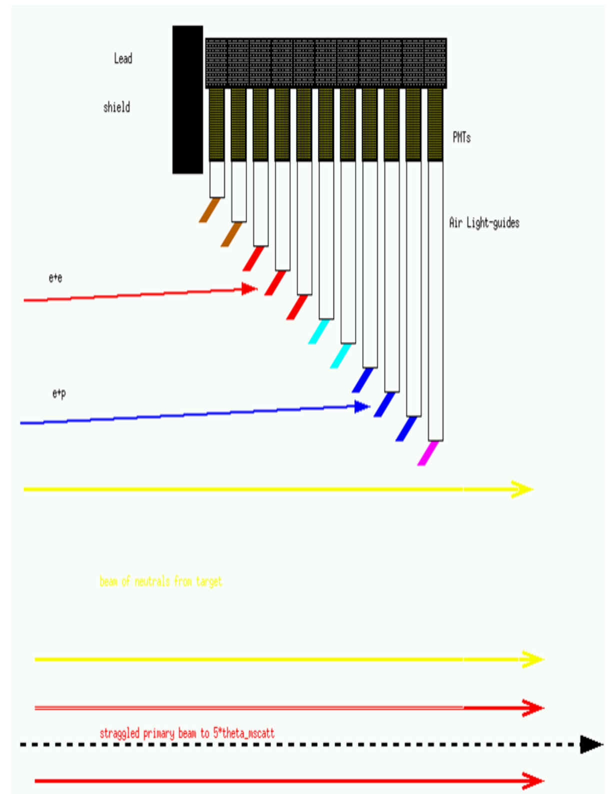


--Rad-hard flux, integrating detectors

--Radial segmentation for systematic checks (backgrounds)

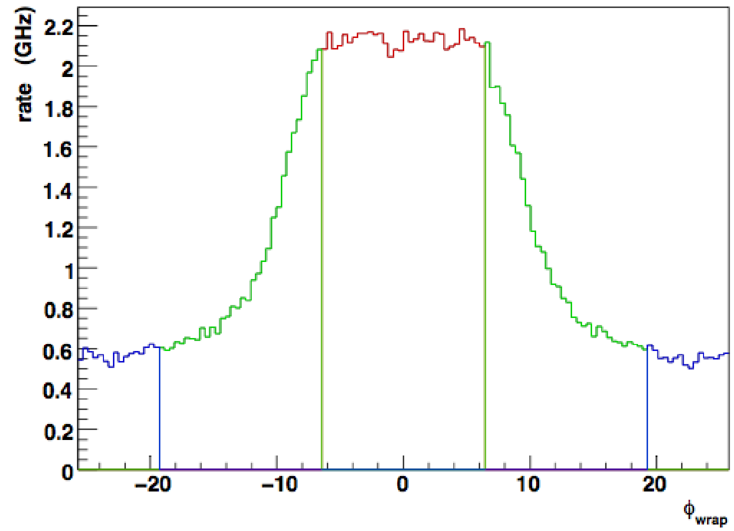
--Azimuthal segmentation for systematic checks (e.g. parity conserving cos(ϕ) asym, azimuthal defocusing, beam sensitivities, backgrounds, etc.)

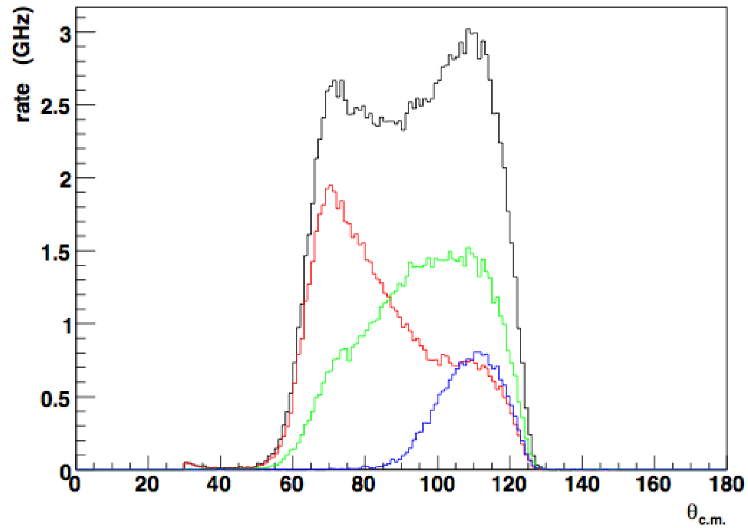
--Ancillary detectors (not shown): Tracking, pion, and lumi

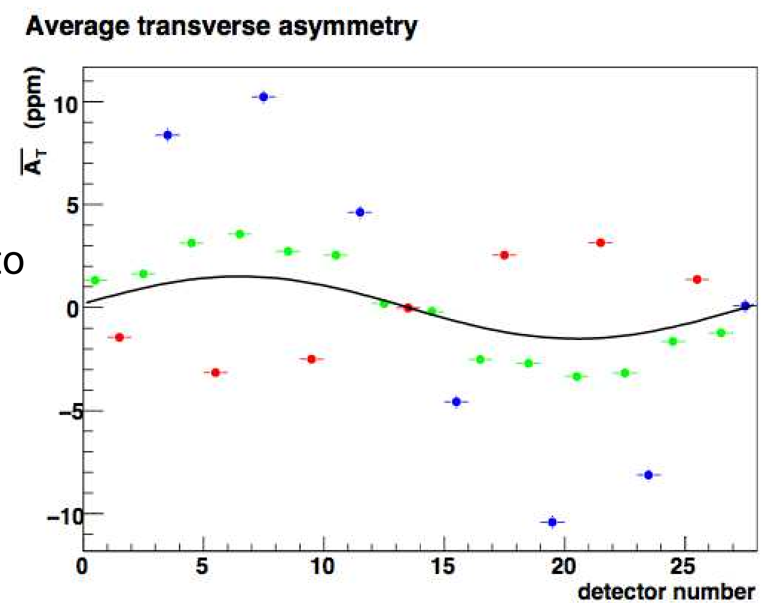


Side View

Transverse Asymmetry Measurement







--A_T ~ 12 parts per million ... 3 orders of magnitude bigger than A_{PV}

--We must be sure that this averages to a negligible contribution!

New Challenges

- 150GHz total detected Moller event rate
  $\longrightarrow$ Must flip pockels cell at $\sim$2kHz
  $\longrightarrow$ 80ppm pulse-to-pulse statistical fluctuations
  - Electronic noise and density fluctuations $< 10^{-5}$
  - Pulse-to-pulse beam monitoring res. a few microns at 1kHz
- 0.5nm/0.05nrad control of beam on target
  $\longrightarrow$ Requires improvement on control of pol. src. laser transport
  $\longrightarrow$ Improved methods of “slow helicity reversal” (double wien)
- Target requires $\sim$5kW of cooling power at 85μA I_{beam}
- Full azimuthal acceptance with θ_{lab} between 5 and 17mrad
  $\longrightarrow$ Aggressive spectrometer design
  $\longrightarrow$ Complex collimation and shielding issues
- Robust and redundant 0.4% beam polarimetry
  $\longrightarrow$ Plan to pursue both Compton and atomic Hydrogen techniques

Timeline and Status

- PAC 34 - full approval - strong endorsement

“The proposed physics reach is outstanding and capable of making this effort a flagship experiment at JLab. The PAC believes the mission of this experiment... is so important that the Laboratory should make every effort to support the securing of the resources required”

- Working with lab management to prepare funding request (DOE nuclear,+...)
- Goals:
  $\rightarrow$ CD-0 request targeted for spring 2010
  $\rightarrow$ construction 2012 - 2015
- First review (Jlab initiated) late this year